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ELECTROTECHNICAL VOCABULARY

PART IV ELECTRON TUBES AND VALVES

Section 3 Microwave Tubes and Valves

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 1

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PART IV ELECTRON TUBES AND VALVES
Section 3 Microwave Tubes and Valves

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Indian Standard
ELECTROTECHNICAL VOCABULARY
PART IV ELECTRON TUBES AND VALVES
Section 3 Microwave Tubes and Valves

0. FOREWORD

0.1 This Indian Standard (Part IV/Sec 3) was adopted by the Indian Standards Institution on 31 August 1970, after the draft finalized by the Electrotechnical Standards Sectional Committee in consultation with the Electron Tubes and Valves Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard deals with terminology relating to microwave tubes and valves.

0.2.1 A number of basic terms relating to microwave tubes have the same definitions as given in IS: 1885 (Part IV/Sec 1)-1965* and have not generally been included in the present document. However, those terms which, though already given in the standard mentioned above, have a somewhat different or special meaning when applied to microwave tubes have been redefined in this standard.

0.3 While preparing this standard, assistance has been derived from the various IEC documents on microwave tubes and valves and IEC Pub 235-1 ‘ Measurement of the electrical properties of microwave tubes and valves, Part 1 : General terms and definitions ’, issued by the International Electrotechnical Commission.

0.4 This standard is one of a series of standards on electron tubes and valves. A list of standards so far published in this series is given on the fourth cover page.

0.5 The terms ‘ tube ’ and ‘ valve ’ being synonymous, for the sake of simplicity, the term ‘ tube ’ has been used in the various terms and definitions throughout this standard.

1. SCOPE

1.1 This standard (Part IV/Sec 3) covers definitions of terms relating to microwave electron tubes.

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*Electrotechnical vocabulary: Part IV Electron tubes and valves, Section 1 Receiving valves.

2. GENERAL

2.1 Microwave — Electromagnetic wave of sufficiently high frequency which requires the use of distributed element circuit techniques in its transmission and reception [*see also* **3.8** of IS : 1885 (Part XVIII)-1967*].

NOTE — Lateral dimensions of the circuits, transmission line components, etc, used at these frequencies are generally comparable to the wave-lengths of operation.

2.2 Plasma — An ionized gaseous medium in which free electron and ion concentrations are nearly equal.

2.3 Plasma Frequency — A natural frequency for coherent motion of electrons in a plasma. It is directly proportional to the square root of the product of the electronic specific charge and the electron density.

2.4 Cyclotron Frequency — The frequency at which an electron in motion traverses an orbit in a steady and uniform magnetic field, and zero electric field. It is given by:

$$\frac{\text{electron charge} \times \text{magnetic flux density}}{2\pi \times \text{electron mass}}$$

2.5 Space-Charge Wave — An electromechanical wave in a plasma or electron stream, produced by oscillating motions of charges. The wave is longitudinal in that the electric field is in the direction of propagation.

2.6 Vacuum Factor — The ratio of the ionic current and the electronic current which generates it, in an electron vacuum tube.

2.7 Extended Interaction — Interaction between an electron beam or stream and a nearly synchronous travelling radio frequency wave over a physical distance comparable to (or greater than) a wave-length.

2.8 Integral (Packaged) Tube — A microwave tube, magnetron, travelling-wave tube, etc, in which the magnet(s) [permanent magnet(s) or electron magnet(s)] and the input or output radio frequency circuits form integral parts of the tube.

2.9 Arcing — Unwanted surges of current due to internal flashover.

2.10 X-ray Shielding — The prescribed geometrical configuration of the stated X-ray absorptive materials.

3. MICROWAVE TUBES

3.1 Microwave Tube — An electron tube intended for operating at microwave frequencies. A microwave tube is designed in conjunction with its radio frequency circuit to provide effective electron interaction.

NOTE 1 — In many tubes, the radio frequency circuit is contained within the vacuum envelop itself, and the electrode terminals do not need to conduct radio frequency signals.

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*Electrotechnical vocabulary : Part XVIII General terms on radio communications.

NOTE 2 — The dimensions of the radio frequency circuit and of the tube itself are generally comparable to the wave-length of operation, and the electron transit times are of the same order as the radio frequency wave period.

3.2 Space-Charge-Controlled Tube — An electron tube whose operation is based on the control of space-charge-limited current emission by voltage(s) applied to a gating electrode(s), and is characterized by density modulation of electrons.

NOTE — Conventional tubes like diodes, triodes, etc, belong to this category.

3.2.1 *Space-Charge-Controlled Microwave Tube* — A space-charge-controlled electron tube designed or intended to operate at microwave frequencies. In these tubes, some of the electrodes form part of the radio frequency (microwave) circuit.

NOTE — In these tubes, the electrodes may often be small as compared to the operating wave-length.

3.2.1.1 *Planar tube* — A space-charge-controlled microwave tube in which the electrodes are in the form of closely-spaced parallel planes and have very short external connections.

NOTE — Light house tubes belong to this category.

3.2.1.2 *Pencil tube* — A space-charge-controlled microwave tube in which the electrodes are coaxial cylinders.

NOTE 1 — The associated radio frequency (microwave) circuits for planar and pencil tubes are external to the vacuum envelope.

NOTE 2 — Since one or more electrodes of planar and pencil tubes may have their external connections in the form of disks, they are also called ‘ disk-seal tubes ’.

3.3 Transit-Time Microwave Tube — A microwave tube whose operation makes use of transit-time effects and which is characterized by velocity modulation of the electron beam or stream. The velocity modulation is followed by bunching of the electrons in the beam or stream.

NOTE — These tubes are also called ‘ velocity-modulation microwave tubes ’.

3.3.1 *Drift Space Microwave Tube* — A transit-time microwave tube characterized by the fact that, after velocity modulation of the electrons, bunching takes place in a region in which no external radio frequency fields interact with the electrons (the only radio frequency fields present in this region are those produced by the electron space charge).

3.3.2 *Growing-Wave Microwave Tube* — A transit-time microwave tube whose operation is characterized by extended interaction between a travelling radio frequency wave and an electron beam travelling with the wave at nearly synchronous velocity and containing at least one component of convection current, whose amplitude grows exponentially with distance.

3.4 Klystron — A drift space microwave tube in which the electron beam is velocity-modulated by passage through a resonant cavity (input cavity) excited by a radio frequency signal, is allowed to drift while density modulation develops, and then passes through output cavity from which the radio frequency power is extracted.

NOTE — Klystrons are available both as amplifiers (klystron amplifiers) and as oscillators (klystron oscillators).

3.4.1 *High Power Klystron* — A klystron with low-interception gaps designed specifically for maximum power output.

3.4.2 *Reflex Klystron* — A single-resonator klystron oscillator in which the direction of the bunched-electron beam is reversed during the drift period, so that it passes a second time through the same cavity, providing the feedback necessary for oscillation.

3.4.3 *Multiple Beam Klystron* — A klystron amplifier having more than one electron beam (and electron gun) with resonators coupled laterally but not axially.

3.4.4 *Frequency-Multiplier Klystron* — A klystron in which the resonant frequency of the output cavity is a desired harmonic of the resonant frequency of the input cavity.

3.4.5 *Multicavity Klystron* — A klystron amplifier in which the beam interacts with additional cavities between the input and output cavities, in order to increase the gain or bandwidth, or both.

3.4.6 *Floating-Drift Tube Klystron* — A klystron oscillator in which the drift region is a shielded region within a single radio frequency cavity.

3.4.7 *Axially-Extended Interaction Klystron* — A klystron utilizing an output circuit having more than one interaction gap.

NOTE — ' Twystron ' is an example of this type of tubes.

3.5 **O-Type Microwave Tube** — A growing-wave microwave tube in which the beam, the circuit and the focusing field(s) are symmetrical about a common axis (no transverse static fields are required for the basic operation of these tubes). Such tubes have linear structures.

3.5.1 *Travelling-Wave Amplifier Tube* (*TWT*) — An O-type microwave amplifier tube characterized by extended interaction between its electron beam and a forward wave produced by one or more slow-wave circuits which are in sequence along the beam and may be separated by attenuators or severs (circuit breaker). Such a tube has a very wide instantaneous frequency bandwidth.

NOTE — This tube is also called O-type forward-wave amplifier tube.

3.5.2 *Backward-Wave Tube, O-Type* — An O-type microwave tube characterized by extended interaction between its electron beam and a backward wave produced by a slow-wave circuit. Such a tube is electronically tunable, that is, its operating frequency may be changed by changing the accelerating voltage of the beam.

3.5.2.1 *Backward-wave amplifier tube, O-type* — A backward-wave, O-type tube designed or intended for use as an amplifier.

3.5.2.2 *Backward-wave oscillator tube, O-type (O-BWO)* — A backward-wave O-type tube designed or intended for generation of microwaves. The necessary feedback is provided internally by the electron beam.

NOTE — This tube is also called ' O-carcinotron '.

3.6 Crossed Field (M-Type) Microwave Tube — A microwave tube characterized by an electric field and a static magnetic field which are perpendicular to each other (crossed) and also to the direction of radio frequency wave propagation on the associated slow-wave circuit.

NOTE — The electric field may be produced by the application of ac/dc (or a pulsed) voltage to the appropriate electrodes.

3.6.1 *Non-re-entrant Beam Crossed Field Forward-Wave Amplifier Tube* — A crossed field, growing-wave, microwave amplifier tube characterized by interaction between a non-re-entrant electron beam and a forward-wave propagating on a non-re-entrant slow-wave circuit.

NOTE 1 — This tube is also called ' magnetron amplifiers '.

NOTE 2 — This tube can have either a linear geometry (linear crossed field amplifier), or a circular geometry (TPO-M, for example).

3.6.2 *Non-re-entrant Beam Crossed Field Backward-Wave Amplifier Tube* — A crossed field, growing-wave, microwave amplifier tube characterized by interaction between a non-re-entrant electron beam and a backward-wave propagating on a non-re-entrant slow-wave circuit.

3.6.3 *Non-re-entrant Beam Crossed Field Backward-Wave Oscillator Tube (M-BWO)* — A crossed field, growing-wave, microwave oscillator tube characterized by interaction between a non-re-entrant electron beam and a backward wave propagating on a non-re-entrant slow-wave circuit.

NOTE — This tube is also called ' M-carcinotrons '.

3.6.4 *Re-entrant Beam Crossed Field Amplifier Tube* — A crossed field, growing-wave, microwave amplifier tube characterized by interaction between a re-entrant electron beam and either a forward-wave (or a backward-wave) propagating on a non-re-entrant slow-wave circuit.

NOTE — ' Amplitrons ' is an example of this type of crossed field tube.

3.6.5 *Re-entrant Beam Crossed Field Backward-Wave Oscillator Tube* — A crossed field backward-wave oscillator tube having a re-entrant electron beam and a non-re-entrant slow-wave circuit.

NOTE — These tubes are also called ' stabilitrons '.

3.7 Magnetron — A transit-time, crossed field, microwave oscillator tube, characterized by a re-entrant slow-wave circuit of circular cylindrical geometry, which also serves as the anode. The static magnetic field is along the axis of the cylindrical anode.

3.7.1 *CW Magnetron* — A magnetron designed to be operated with dc, ac or unfiltered rectified voltage supply.

3.7.2 *Pulsed Magnetron* — A magnetron designed to be operated under pulsed conditions.

3.7.3 *Travelling-Wave Magnetron* — A magnetron whose operation depends upon the interaction of electrons with a travelling radio frequency field having constant angular or linear velocity.

NOTE 1 — Generally, travelling-wave magnetron has an anode structure, consisting of several cavity resonators and hence is also called '*multicavity magnetron*'.

NOTE 2 — Some of the common forms of anode structures of multicavity magnetrons are:

a) Hole and slot anode,
b) Vane anode,
c) Rising-sun anode,
d) Interdigital anode, and
e) Slot anode.

3.7.4 *Voltage-Tunable Magnetron* (*VTM*) — A magnetron in which, the output frequency can be varied linearly by varying the anode voltage. This is achieved by virtue of controlled electron injection and a heavily-loaded radio frequency circuit.

NOTE — These are generally intended for CW operation.

3.7.5 *Coaxial Magnetron* — A multicavity magnetron featuring a coaxial cavity surrounding the cavity resonators. Radio frequency output is coupled out from the coaxial cavity.

4. ELECTRON BEAMS, ELECTRON GUNS, ELECTRODES, ETC

4.1 Cold Cathode (CC) — A cathode that does not require heating to produce the desired emission.

4.2 Hot Cathode — A cathode which requires heating to produce the desired thermionic emission.

NOTE — This cathode is also called '*thermionic cathode*'.

4.3 Electron Beam — A beam of electrons moving in paths that are confined to a desired region.

4.3.1 *Re-entrant Electron Beam* — An electron beam or stream traversing a circular path and of which at least some part makes more than one complete round of the path.

4.3.2 *Laminar-Flow Electron Beam* — An electron beam in which all electron trajectories bear a similar relationship to each other (no trajectory crossing) all along the beam, and the beam shape is determined by the path of the beam-edge electrons.

4.3.3 *Non-laminar-Flow Electron Beam* — An electron beam in which electron trajectories cross each other along the beam. This is due mainly to : (a) aberrations in the electron gun, or (b) transverse thermal velocities of the electrons, or both.

4.3.4 *Axially-Symmetrical Electron Beam* — An electron beam which is symmetrical about its axis. It is produced by an axially-symmetrical electron gun whose axis is collinear with the beam axis.

4.3.5 *Converging Electron Beam* — An electron beam whose one or more lateral dimensions decrease (and hence, whose current density increases) as one moves away from the cathode.

4.3.6 *Scalloping (of an Electron Beam)* — Periodic variation of the lateral dimensions of an electron beam along its length.

4.3.7 *Beam Compression (at a Point Along the Axis)* — The ratio between the area of the emitting surface, and the cross-sectional area of the electron beam at that point.

4.3.8 *Electron Beam Transmission Efficiency (of an Electron Beam Tube)* — The ratio expressed (as a percentage) under stated conditions, between the average beam current collected by the collector electrode, and the total average beam current.

4.3.9 *Electron Beam Transmission Efficiency (of an Electron Tube)* — The ratio (expressed as a percentage) under stated conditions, between the average beam current passing through an electrode or structure of an electron tube, and the average beam current approaching the electrode or structure.

4.3.10 *Perveance (of an Electron Beam)* — The ratio of the total electron beam current (in amperes) and the three-halves power of the voltage (in volts) corresponding to the average beam velocity, in the interaction region of the microwave tube.

Note — The unit of perveance is ' perv '. However, perveance is generally expressed in terms of micro-pervs.

4.4 Immersed Flow — A condition of electron beam flow in which the entire beam region, including the gun and the cathode, is immersed in a uniform magnetic field.

The emitting surface of the cathode is normal to the magnetic field. Also, the axial velocities of the beam electrons across any cross section are not uniform (slipping-stream beam).

Note — It is also called 'confined flow'.

4.5 Brillouin Flow — A condition of electron beam flow, in the presence of a uniform axial magnetic field in the beam region and no magnetic flux in the gun region (shielded gun), such that the centrifugal, space-charge and magnetic forces acting on the electrons, are balanced producing a smooth beam, that is, a beam of uniform cross section.

NOTE — Ideally, all the electrons in a Brillouin-flow beam have the same axial velocity.

4.6 Electron Trajectory — Path of an electron in a beam.

4.7 Space Charge — Net electric charge in a region of space.

4.8 Space-Charge Density — The space charge per unit volume.

4.9 Interaction Region — Space in which an electron beam is exposed to the influence of an radio frequency field, or *vice versa.*

4.10 Interaction Gap — A relatively narrow interaction region.

4.11 Transit Time — The time taken by a charge carrier in traversing a stated space.

4.12 Transit Angle — The product of the transit time, and the angular frequency of the sinusoidal component of the current.

4.13 Drift Space — A space in an electron tube which is free of external radio frequency fields and through which an electron beam or stream passes. The only radio frequency fields present in this region are those produced by the electron space charge.

4.14 Drift Tube (Drift Tunnel) — A length of metal tubing, held at a fixed potential, which forms a drift space in an electron tube.

4.15 Electron Beam Tube — An electron tube whose performance depends on the formation and control of one or more electron beams.

4.16 Density Modulation

a) The process of varying, with time, the density of charge carriers.
b) The condition existing in a charge carrier stream as a result of (a).

4.17 Velocity Modulation

a) The process of varying, with time, the velocity of charge carriers.
b) The condition existing in a charge carrier stream as a result of (a).

4.17.1 *Depth of Velocity Modulation* — The ratio between the amplitude of a stated frequency component of the varying velocity of an electron beam, and the average beam velocity.

4.18 Bunching — The conversion of velocity modulation of an electron beam into density modulation.

In the process, the beam, initially continuous, becomes a succession of regions of electron density higher than the average beam density (*bunches*), centred about unaccelerated electrons.

4.18.1 *Bunching Angle (in an Electron Beam or Stream)* — The average transit angle, in a given drift space, between the processes of velocity modulation and radio frequency energy extraction at the same (or different) gap(s).

4.18.2 *Effective Bunching Angle* — The transit angle that would be required in a hypothetical drift space in which the voltages vary linearly over the same range as in the given drift space, and in which the result of the bunching action is the same as in the given drift space.

4.18.3 *Space-Charge Debunching* — The process of dispersal of the electrons of a bunch in an electron beam, because of mutual interaction between the electrons in the bunch.

4.19 Synchronism Voltage — The voltage necessary to accelerate the electrons from the rest position to a velocity equal to the phase velocity of a component of an electromagnetic wave propagated by a slow-wave structure.

4.20 Electron Gun — An electrode structure consisting of a cathode and other electrodes, which produces and forms an electron beam of required shape, size and perveance, and which may also provide control in respect of its current density and velocity.

4.20.1 *Axially-Symmetrical Electron Gun* — An electron gun whose structure and individual electrodes are symmetrical about a common axis.

4.20.2 *Shielded Electron Gun* — An electron gun in which no portion of the static magnetic field used elsewhere in the tube, is allowed to penetrate into the beam-forming region and to thread through the emitting surface of the cathode. Suitable magnetic shielding is used for this purpose.

4.20.2.1 *Shielded cathode* — Cathode of a shielded electron gun.

4.20.3 *Partially-Shielded Electron Gun* — An electron gun in which a portion of the static magnetic field used elsewhere in the tube, is allowed to penetrate into the beam-forming region and to thread through the emitting surface of the cathode.

The shape of the lines, and the intensity of the penetrating magnetic field have to be controlled by a careful design of the magnetic circuit.

4.20.3.1 *Partially-shielded cathode* — Cathode of a partially-shielded electron gun.

4.20.4 *Immersed Electron Gun* — An electron gun, designed to operate under immersed-flow condition.

4.20.5 *Planar Pierce Gun* — An immersed electron gun, in which the emitting surface of the cathode is planar and normal to the gun and beam axis, and the beam has the same size and shape as the emitting surface.

4.20.6 *Convergent or Converging Beam Pierce Gun* — An electron gun, which forms and delivers an initially converging beam by the use of electrostatic fields only in the gun region.

4.20.7 *Magnetron Injection Gun* (*MIG*) — An electron gun which produces a hollow beam of high total perveance, which flows parallel to the axis of a steady magnetic field.

4.21 Electrodes

4.21.1 *Beam-Forming or Beam-Focusing Electrode* — An electrode located adjacent to the cathode in an electron gun, which causes the fields external to the beam in the gun region, to satisfy the proper boundary conditions at the beam edge so that the beam formed is of the required shape.

4.21.2 *Sole* — An electrode parallel to the slow-wave circuit in a crossed field microwave tube, between which and the slow-wave circuit, an appropriate voltage is applied to obtain the electric field perpendicular to the static magnetic field.

4.21.2.1 *Emitting sole* — A sole which may be a source of electron emission, either thermionic or secondary.

4.21.2.2 *Non-emitting sole* — A sole which is not a source of electron emission.

4.21.3 *Collector* — An electrode that collects the electrons or ions that have completed their function within an electron tube.

4.21.3.1 *Depressed collector* — An insulated collector (of a klystron, travelling-wave tube, crossed field tube, etc) maintained at a potential lower than that which determines the electron velocity in the interaction region, for the purpose of increasing the efficiency of the tube.

5. ELECTRON BEAM FOCUSING AND METHODS

5.1 Focusing (of an Electron Beam) — The process of controlling the divergence, or lateral spread, of an electron beam in order to get a well-defined beam, or to minimize its interception by certain electrodes or structures.

5.1.1 *Uniform-Field Focusing* — Focusing derived from an essentially uniform static-electric (or magnetic) field acting on the electron beam.

5.1.2 *Periodic-Field Focusing* — Focusing derived from the action of periodically-reversed static-electric (or magnetic) fields on the electron beam.

5.2 Electrostatic Focusing — Focusing of an electron beam by the action of electric field.

5.2.1 *Ballistic Focusing (BF)* — Focusing in which static-electric fields cause an initial convergence of the electron beam and the electron trajectories are thereafter determined by the momentum and space-charge forces only.

5.2.2 *Electrostatic Lens Focusing* — A focusing system in which a series of electrodes, at alternately high and low dc potentials, form electrostatic lenses which focus the beam.

5.2.2.1 *Electrostatic focusing potentials* — The electrode potentials, each of which is applied to a stated focusing electrode of an electrostatically-focused tube.

5.3 Magnetic Focusing — Focusing of an electron beam by the action of magnetic field.

5.3.1 *Electromagnetic (EM) Focusing* — Magnetic focusing derived from the use of electromagnet(s) or solenoid(s).

5.3.2 *Permanent-Magnet (PM) Focusing* — Magnetic focusing, derived from the use of permanent magnet(s).

5.4 Uniform-Field Magnetic Focusing — Magnetic focusing derived from an essentially uniform magnetic field in the electron beam region.

5.4.1 *Immersed-Flow Focusing* — Uniform-field magnetic focusing in which the entire region of the electron beam, including the electron gun (and the cathode), is immersed in an axial uniform magnetic field and in which the focusing of the beam results from the tendency of the electrons to follow the magnetic lines of force.

5.4.2 *Brillouin-Flow Focusing* — Uniform-field magnetic focusing derived from the use of an axial uniform magnetic field of such a magnitude that the centrifugal, space-charge and magnetic forces acting on the electrons are balanced, producing a smooth beam, that is a beam of uniform cross section.

NOTE — This focusing method is, theoretically, the most efficient in terms of magnetic field intensity per unit beam perveance.

5.5 Periodic-Magnet Focusing

5.5.1 *Periodic-Electromagnet Focusing* — Magnetic focusing derived from an array of electromagnets or solenoids arranged to produce periodically reversed magnetic fields along the electron beam.

5.5.2 *Periodic Permanent Magnet (PPM) Focusing* — Magnetic focusing derived from an array of permanent magnets arranged to produce periodically reversed magnetic fields along the electron beam.

5.6 Field-Reversal Magnetic Focusing — Magnetic focusing derived from a limited number of magnetic field reversals, not periodic, whose location is usually related to breaks in the slow-wave circuit.

5.6.1 *Field-Reversal Electromagnetic Focusing* — Field-reversal magnetic focusing utilizing solenoids or electromagnets.

5.6.2 *Field-Reversal Permanent Magnet (FRPM) Focusing* — Field-reversal magnetic focusing utilizing permanent magnets.

5.7 Ion or Gas Focusing — Focusing of an electron beam by the action of ionized gas. This results from the neutralization of space-charge repulsion forces in an electron beam, by the ions produced from the residual gas in an electron tube.

6. CIRCUITS

6.1 Lumped Element Circuit — A circuit consisting of discrete inductors and capacitors.

6.2 Distributed Element Circuit — A circuit in which inductance and capacitance are uniformly distributed over physical distances comparable to a wave-length.

6.3 Dispersive Circuit or Structure — A structure in which the phase velocity of the radio frequency wave propagating along it varies with frequency.

6.4 Non-dispersive Circuit or Structure — A structure in which the phase velocity of the radio frequency wave propagating along it does not vary with frequency.

6.5 Slow Wave — An electromagnetic wave whose phase velocity is much less than the velocity of light in free space.

6.6 Slow-Wave Circuit or Structure (SWS) — A radio frequency transmission line, circuit or structure in which the phase velocity of some component(s) of the propagating radio frequency wave is much less than the velocity of light in free space.

NOTE — It is also called ‘ delay line or circuit ’.

6.7 Periodic or Periodically-Loaded Circuit or Structure — A radio frequency circuit or structure which has a periodically recurring structure in the direction of propagation.

NOTE 1 — Such a circuit or structure is generally a slow-wave circuit.

NOTE 2 — The periodicity may be either single or multiple.

6.7.1 *Space or Spatial Harmonic* — A fourier component of the wave-function describing the radio frequency wave propagation along a periodic or periodically-loaded circuit. Because of the spatial periodicity of the propagating circuit, the wave-function can be expressed as a doubly-infinite fourier series in terms of the spatial period.

Note 1 — The group velocity is the same for all harmonics, both in magnitude and direction, at a given frequency.

Note 2 — The phase velocity of a harmonic is different from that of other harmonics (at the same frequency), and can be in the same direction as, or opposite to, that of the group velocity.

Note 3 — A large number of these harmonics can be slow waves, that is, can have phase velocities much less than the velocity of light in free space.

6.7.1.1 *Forward wave, or harmonic* — A radio frequency wave, or space harmonic, of which the phase velocity is in the same direction as the group velocity.

6.7.1.2 *Backward wave or harmonic* — A radio frequency wave, or space harmonic of which the phase velocity and the group velocity are in opposite directions.

6.7.2 *Forward-Wave Circuit or Structure* — A slow-wave circuit or structure whose propagation is characterized on an (ω, β) diagram (angular radio frequency *versus* phase constant) by a positive slope in the region $0 \angle \beta \angle \pi$ (in which the group and phase velocities, therefore, have the same sign).

6.7.3 *Backward-Wave Circuit or Structure* — A slow-wave circuit or structure whose propagation is characterized on an (ω, β) diagram (angular radio frequency *versus* phase constant) by a negative slope in the region $0 \angle \beta \angle \pi$ (in which the group and phase velocities have, therefore, opposite signs).

6.8 Growing Wave — A radio frequency wave, or space harmonic, whose amplitude increases with distance along the radio frequency circuit as a result of extended interaction with an electron beam.

6.9 Re-entrant Circuit or Structure — A radio frequency slow-wave circuit or structure that closes upon itself. Such a circuit has a circular geometry.

6.10 Re-entrant Cavity — A cavity whose axial cross section is a re-entrant polygon. The re-entrant portions usually form tunnels for passage of an electron beam.

6.11 Sever — A break in a slow-wave circuit across which the wave does not propagate. The ends of the sever may be internally terminated, or may be brought out to external connectors.

6.12 Spatial Period — The axial distance after which the structure of a periodic circuit repeats itself.

6.13 (ω, β) Diagram — A rectangular plot showing the angular radio frequency *versus* the phase constant of a periodic circuit.

Note — It is also called ' Brillouin diagram '.

6.14 Interaction Impedance — A parameter, having the dimensions of impedance, which describes the magnitude of the radio frequency electric field of the interacting slow-wave (or space-harmonic), produced in the interaction region for a given radio frequency power flow in a slow-wave circuit.

6.15 Gain Parameter — A quantity which is a function of the product of the interaction impedance of the radio frequency circuit and the admittance of the electron beam in a growing-wave tube, and is a measure of the rate of growth (per guide wave-length) of the growing component of the radio frequency wave in the tube.

6.16 Unloaded Q (Q_1) — 2 π times the ratio of the total stored radio frequency energy and the radio frequency energy dissipated per cycle in the tube only.

6.17 External Q (Q_E) — 2 π times the ratio of the total radio frequency energy stored in the tube and the radio frequency energy dissipated per cycle in the external load only.

6.18 Loaded (Total) Q (Q_L) — 2 π times the ratio of the total stored radio frequency energy in the tube and the radio frequency energy dissipated per cycle in the tube and the external load.

Note — The rate at which the susceptance (of the tube and external load) varies with frequency is a measure of total Q of the circuit.

7. PHYSICAL TERMS

7.1 Mount — The additional equipment, excluding power supplies necessary to operate the tube.

7.2 Cooling Fin(s) — Metallic part(s) or fin(s) extending the radiating area to facilitate dissipation of the heat generated in the device.

7.3 Reference Plane — A specified transverse plane in the input or output radio frequency coupler(s), or connector(s), which may be integral either with the tube or with its associated mount. It is usually given on the outline drawing.

8. TIMING

8.1 H.T. Delay Time — The time interval between the instant at which a given heater or filament voltage is reached and the instant of application of the H.T.

Note — This is also called ' stabilization time '.

8.2 Warm-Up Time — The time interval between the start of application of the H.T. and the moment at which either a given drift rate of, or stated value of, frequency, output power or current is achieved.

8.3 Total Starting Time — The time interval between the start of application of heater or filament voltage and the moment at which either a given drift rate of, or stated value of, frequency, output power, or current is achieved.

9. RADIO FREQUENCY MEASUREMENT

9.1 Measurement Conditions

9.1.1 *Cold Conditions* — Measurement conditions in which no supply voltages are applied to the tube.

9.1.2 *Standby Conditions* — Measurement conditions in which the heater or filament voltage alone is applied to the tube.

9.1.3 *Operating Conditions* — Measurement conditions in which supply voltages, and/or radio frequency signals, are applied to the heater or filament and to all other electrodes of the tube.

9.2 Radio Frequency Load

9.2.1 *Load* — That part of the circuit which lies beyond the output reference plane (away from the tube).

9.2.2 *Matched Load* — A load which does not reflect back any part of the incident radio frequency power.

NOTE — A ' perfectly ' matched load gives rise to a voltage standing wave ratio (VSWR) of unity. However, such a load is unattainable in practice and, hence, it becomes necessary to accept, as a matched load, a mismatched load having a VSWR not exceeding a defined value close to unity.

9.2.3 *Mismatched Load* — A load which reflects back some part of the incident radio frequency power.

NOTE — A mismatched load gives rise to a VSWR greater than unity and it is expressed together with the position of a voltage minimum generally the one nearest to the reference plane by either:

a) its voltage reflection coefficient, or

b) its VSWR (given as a figure greater than that permitted by **9.2.2**).

9.2.4 *Position of Voltage Minimum* — The distance from the reference plane to the nearest minimum of the voltage standing-wave pattern in the given transmission line at a stated frequency. The distance is positive when measured in a direction outward from the tube being measured.

9.3 Output

9.3.0 Unless otherwise specified, ' output ' refers to ' radio frequency output '.

9.3.1 *Output Power* — The power which is delivered by the tube at the output reference plane.

9.3.1.1 *Optimum output power* — The maximum output power which can be obtained by adjustment when a microwave tube is operated under stated conditions.

9.3.2 *Power Stability* — The ability of an amplifier or oscillator tube, when operated under given conditions, to re-establish the original value of output power after an interruption of the H.T. supply.

NOTE — The change in output power is usually expressed as a percentage of the initial value.

9.3.3 *Restartability* — The ability of an amplifier or oscillator tube to re-establish, on restoration of stated operating conditions without any adjustment, the original value of output power after a specified period under cold conditions following a specified operating period under the same stated operating conditions.

NOTE — The change in output power is usually expressed in decibels.

9.3.4 *Efficiency* — The ratio of the output radio frequency power, and the total input power to the tube excluding the cathode heating supply power and that part of the driving power having the same frequency as the output power or a submultiple thereof. The output and input powers are measured over a stated period of time.

NOTE — This is usually expressed as a percentage.

9.3.5 *Electronic Efficiency* — The ratio of output radio frequency power at the desired frequency delivered by the electron beam or stream to the circuit in a tube and the average power supplied to the beam or stream.

9.3.6 *Spectrum Width* — The difference in frequency between the most widely separated points at which the power per unit frequency is a specified fraction (usually one-fourth) of the highest value occurring in the spectrum.

9.3.7 *Rieke Diagram* — A chart showing contours of constant power output and constant frequency of a microwave oscillator tube, drawn on a polar diagram whose coordinates represent the components of the complex voltage reflection coefficient at the tube load.

9.3.8 *Mismatch Stability* — The ability of a microwave tube when operated under stated conditions, to give a stable performance without unwanted oscillation, when input and/or output is (are) terminated in mismatched loads of stated VSWR, the position of voltage minimum being independently moved through distances greater than one-half guide wavelength.

9.3.9 *Optimum Depressed Collector Conditions* — That combination of depressed collector operating conditions which gives the stated minimum output at maximum efficiency.

9.3.10 *Δ V-AM Coefficient*

9.3.10.1 *Output power sensitivity to variation of an electrode voltage* — The ratio of the change of output power to the causative change of electrode voltage, thermal effects included.

9.3.10.2 *Output power sensitivity to modulation of an electrode voltage* — The ratio of the change of output power, to the causative change of electrode voltage (due to modulation), thermal effects excluded.

9.3.11 *Emission Stability* — The ability of a microwave tube to continue operating (in respect of output power, frequency, cathode current, etc) within specified limits, when the heater or filament power is reduced by a stated amount.

NOTE — The change in the measured quantity is a measure of emission stability.

9.4 Radio Frequency Noise* — Noise generated in a microwave tube in the microwave frequency band.

NOTE 1 — Only those ' noise ' terms which have particular relevance to microwave tubes are specified in this clause.

NOTE 2 — The term ' noise ' refers to ' radio frequency noise ' in this standard, unless otherwise specified.

9.4.1 *Spurious Mode Oscillations* — Unwanted oscillations occurring in undesired modes, usually in frequency regions other than that required.

9.4.2 *Interpulse Noise* — Excess radio frequency noise occurring during off-period conditions, measured in a stated bandwidth.

9.4.3 *Intrapulse Noise* — Excess radio frequency noise occurring during on-period conditions.

9.4.3.1 *Intrapulse noise (non-active conditions)* — Excess radio frequency noise occurring during on-period non-active conditions.

9.4.3.2 *Intrapulse noise (active conditions)* — Excess radio frequency noise occurring during on-period active conditions.

9.4.4 *Noise Temperature* — The temperature at which a hypothetical resistor shall be set so that it delivers the same noise power as the source to which it is equivalent.

9.4.4.1 *Reference noise temperature* — The temperature of a source delivering reference noise power.

9.4.4.2 *Excess noise temperature* — The difference between the noise temperature of the tube being measured, or a noise source, and a reference noise temperature.

9.4.4.3 *Equivalent (or effective) noise temperature* — The noise temperature of a tube when it is different from the physical temperature of the source of noise, such as in a gas discharge noise tube or electron beam noise generator.

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*For general noise terms, reference may be made to IS : 1885 (Part IV /Sec ...)-1970 ' Electrotechnical vocabulary: Part IV Electron tubes and valves, Section ... Noise in microwave tubes (*under preparation*)'.

9.4.4.4 *Effective input noise temperature* — The excess noise temperature of an amplifier referred to its input; or the excess noise temperature necessary at the input of an equivalent noiseless amplifier to produce the same noise power at the output of the real amplifier with an input termination at reference temperature.

9.4.4.5 *Operating noise temperature* — The noise temperature of an amplifier referred to its input; or the noise temperature necessary at the input of an equivalent noiseless amplifier to produce the same noise power at the output of the real amplifier with an input termination at reference temperature.

9.4.5 *Noise Temperature Ratio* — The ratio of noise temperature to reference noise temperature.

9.4.6 *Excess Noise Ratio* (*ENR*) — The ratio of excess noise temperature to reference noise temperature. This may also be given as the ratio of excess noise power to reference noise power.

10. TUNING

10.1 General Terms

10.1.1 *Frequency Tuning Range* — The frequency range over which a microwave tube may be tuned when operated under given conditions whilst delivering a required minimum output power.

NOTE — The tuning may be either mechanical or electronic.

10.1.2 *Tuning Sensitivity* — The rate of tuning with respect to a change of the controlling parameter, for example, the position of mechanical tuner or electronic tuning voltage, at a given operating point.

10.1.3 *Tuning Rate or Tuning Speed* — The time rate of change of frequency of operation usually expressed in megahertz per second per second.

10.1.4 *Tuner Resettability* — The ability of the tuning mechanism to reproduce the same value of a stated quantity, for example, frequency or output power, at the same tuner setting.

10.1.4.1 *Unidirectional tuner resettability* — Tuner resettability when a tuner setting is always approached from the same direction.

10.2 Mechanical Tuning

10.2.1 *Tuner Backlash* — The maximum amount of motion of the tuner, which does not produce a change in the value of a stated quantity, for example, frequency or output power, on reversal of the direction of tuner motion.

10.2.2 *Tuner Hysteresis* — The difference between the values of a stated quantity, for example, frequency or output power, observed when a given tuner setting is approached from opposite directions. Tuner hysteresis may include backlash.

10.2.3 *Tuner Overrun* — Continuing change of a stated quantity, for example, frequency or output power, after the tuner motion has ceased.

10.2.4 *Tuner Drift* — A slow continuous change of the characteristic of frequency or output power *versus* tuner setting, caused by unwanted changes in the tuner.

10.2.5 *Tuner Creep* — Variation from the tuner calibration curve as a result of multiple cycling of the tuner.

10.2.6 *Tuner Breakaway Torque* — The value of torque required to initiate tuner motion.

NOTE — This is also called ‘ tuner starting torque ’.

10.2.7 *Tuner Running Torque* — The value of torque required to drive the tuner over the entire tuning range at a stated temperature.

10.2.8 *Tuner Fatigue* — A deterioration in the performance of the tuner and/or of other related mechanical parts of the tube occurring as a result of repeated tuning cycles.

10.2.9 *Tuner Stop* — A portion of the tuning mechanism which serves as a mechanical limit on tuner travel.

NOTE — As a precaution, it may be necessary to limit inertial forces on the drive linkage.

10.2.10 *Tuner Stop Torque or Force* — The maximum torque or force including inertia and/or impact components, which the parts of the tuner mechanism can withstand at the end of the travel without sustaining damage.

10.3 Electronic Tuning

10.3.1 *Electronic Tuning Non-linearity* — Deviation, from a straight line, of the characteristic of the frequency of oscillation, or of maximum output power *versus* electronic tuning voltage, expressed as a percentage of the tuning voltage.

10.3.2 *Electronic Tuning Hysteresis* — The existence of a double-valued range in the characteristic of frequency (or output power) *versus* electronic tuning voltage when the latter is swept in both directions.

10.4 Tuning Discontinuity — Abrupt changes in frequency or power which are the consequence of variations of the tuner setting.

11. PULSE TERMS APPLICABLE TO MICROWAVE TUBES

11.0 General

11.0.1 Only those pulse terms having particular reference to microwave tubes are specified under this clause.

11.0.2 The quantitative definitions of some of the pulse characteristics, particularly those relating to voltage and current pulses, have to be different for beam or O-type tubes and crossed field or M-type tubes, because they obey different voltage-current relations. The measurement points for these pulses have, therefore, to be adjusted appropriately for different types of tubes. There are, however, no differences in the definitions of ' power-pulse characteristics ' for the various tubes.

11.1 Pulse Duration — The time interval between the instants at which the instantaneous value of the pulse quantity equals a stated value of the pulse amplitude.

NOTE — Recommended measurement points are as follows:

Pulses	*Type of Tube, Percent*	
	Beam	Crossed field
Power	50	50
Current	70	50
Voltage	70	70 to 90

11.2 Pulse Stability

11.2.1 *Missing Pulse* — A pulse whose energy in the stated frequency band is less than some stated fraction of the energy of a normal output pulse.

NOTE — The stated fraction of the normal output pulse energy is usually 70 percent.

11.2.2 *Missing-Pulse Count* — A count of input pulses over a stated period for which corresponding output pulses are missing.

11.2.3 *Missing-Pulse Factor* — The ratio of the missing-pulse count and the total count of input pulses, both counts being measured in the same period.

11.2.4 *Pulse Starting Stability* — The ability of a microwave tube to operate without missing pulses after the first application, in a stated manner, of the operating supply voltage(s).

NOTE — A measure of the pulse starting stability is the missing-pulse factor determined directly after a period of rest.

11.3 Mismatch Pulse Stability — The maximum value of the missing-pulse factor, measured under stated operating conditions, when the phase of the reflection coefficient of a load of specified VSWR (usually 1·5) is varied over at least π radians.

11.4 Pulse Jitter — Random variations in the characteristic of successive pulses, for example, energy content, time, frequency or amplitude. It may be expressed as an rms value of the deviations from the average value.

11.4.1 *Pulse Time Jitter* — A pulse-to-pulse variation of the time incidence of a given level of the pulse, with respect to a given level of the initiating pulse.

11.4.2 *Pulse Frequency Jitter* — A pulse-to-pulse variation of the radio frequency of oscillation, occurring at corresponding instants within the pulse.

11.4.3 *Pulse Amplitude Jitter* — A pulse-to-pulse variation of the pulse amplitude of the instantaneous value occurring at corresponding instants within the pulse.

11.4.4 *Pulse Phase Jitter* — A pulse-to-pulse variation of the radio frequency phase delay introduced by the amplifier tube, occurring at corresponding instants within the pulse.

11.5 Cathode Loading Factor — The product of the maximum rate-of-rise of cathode current and the maximum cathode current, expressed as amperes squared per microsecond.

11.6 Peak Envelope Power/Peak Pulse Power — The maximum value of output power in a stated time interval, spikes excluded.

NOTE — The ' pulse output power ' is synonymous with ' peak pulse power '.

12. MEASUREMENT CONDITIONS

12.1 On-Period Conditions — Measurement conditions during the part of an operating cycle in which the tube is conducting.

12.2 On-Period, Active Conditions — Measurement conditions during that part of an operating cycle in which the tube is conducting and during the occurrence of a radio frequency pulse.

12.3 On-Period, Non-active Conditions — Measurement conditions during that part of an operating cycle in which the tube is conducting but when no driving power is applied.

12.4 Off-Period Conditions — Measurement conditions during that part of an operating cycle in which the tube is non-conducting.

13. TERMS APPLICABLE TO AMPLIFIER TUBES

13.1 Frequency

13.1.1 *Frequency Tuning Range* — The frequency range over with the amplifier tube may be adjusted, then operated under given conditions, to give a required minimum power gain or output power.

13.1.2 *Instantaneous Bandwidth* — The frequency interval over which the available power gain of an amplifier tube, operating under stated fixed conditions, varies within prescribed limits, the rate of the frequency change being rapid enough to exclude all thermal drift effects.

13.2 Drive

13.2.1 *Radio Frequency Input Power* — The radio frequency power which is delivered to the amplifier tube at the input reference plane.

NOTE — This is also called ‘ driving power ’.

13.2.2 *Available Driving Power* — The radio frequency power that would be delivered into a matched load substituted for the amplifier tube at the input reference plane.

13.3 Gain

13.3.1 *Power Gain* — The ratio of the output power of an amplifier tube operated under given conditions and the driving power. This ratio is usually expressed in decibels.

13.3.1.1 *Optimum gain* — The maximum gain which can be obtained by adjustment, when a microwave tube is operated under stated conditions.

13.3.2 *Available Power Gain* — The ratio of the output power of an amplifier tube, operated under given conditions and the available driving power. This ratio is usually expressed in decibels.

13.3.3 *Incremental Power Gain* — The ratio of the incremental increase of output power and the small increment of driving power producing it, at a stated driving (or output) power. Both the incremental values are expressed numerically (that is, not in decibels).

13.3.4 *Differential Gain* — The decibel difference of the values of incremental gain at two stated levels of radio frequency input power.

13.3.5 *Small-Signal Gain* — Power gain in the driving power range in which a further decrease of the driving power has no effect on the gain.

13.3.6 *Gain Flatness* — The difference between maximum and minimum values of power gain over a given frequency band, gain ripple included.

13.3.7 *Gain Ripple*

a) The difference between the maximum and minimum values of power gain over a given frequency increment about a stated frequency.

b) The maximum difference in power gain between adjacent peaks and valleys in the gain *versus* frequency characteristic at the most unfavourable part in the operating frequency range.

NOTE — This is also called ' gain fine-grain structure '.

13.3.8 *Gain-Box* — A defined area on the graph of the gain *versus* frequency characteristic, within which all gain variations are expected to remain.

13.3.9 *Synchronous Gain* — The small-signal gain of an amplifier tube under following conditions:

a) *Klystrons with resonant structures* — All resonant circuits are tuned to reproduce maximum output at small-signal drive (this gain value is greater than that of the small-signal gain realized when the tube is tuned to provide maximum output at large-signal drive); or

b) *Growing-wave tubes* — The electron beam average velocity is equal to the phase-velocity of the interacting component of the radio frequency wave on the slow-wave circuit.

13.3.10 *Gain Slope* — The maximum rate of change of gain with respect to frequency, within a stated frequency interval.

13.3.11 *Gain Constancy* — The change of power gain relative to small signal gain, with variation of the driving power, when the tube is operating under stated conditions. It is a measure of gain linearity and is usually expressed in decibels.

13.3.12 *Compression* — A process in which the gain of a tube is a function of the magnitude of the input signal.

13.3.13 *Compression Factor* — The ratio of the difference between the power gain and the incremental power gain, and the power gain.

13.3.14 *Saturation Gain* — The available power gain at saturation power.

13.3.15 *Gain at Nominal Power* — The available power gain when the tube is delivering nominal output power with the beam voltage optimized or as otherwise stated.

13.4 Output Power

13.4.1 *Fundamental Output Power* — The output power of microwave amplifier tube at the frequency of the driving signal.

13.4.2 *Harmonic Output Power* — The output power whose frequency is an integral multiple of the driving signal frequency and which is also coherently related to the driving signal.

13.4.3 *Saturation Power* — The first maximum value of output power observed as the driving power is gradually increased, with the tube operated under stated conditions.

13.5 Reflection Coefficient and Voltage Standing Wave Ratio (VSWR)

13.5.1 *Cold Reflection Coefficient* — The voltage reflection coefficient at the input (or output) of a microwave amplifier tube observed under cold conditions.

13.5.2 *Cold VSWR* — The VSWR at the input (or output) of a microwave amplifier tube observed under cold conditions.

13.5.3 *Operating (or Hot) Reflection Coefficient* — The voltage reflection coefficient of the input (or output) of a microwave amplifier tube, observed under operating conditions.

13.5.4 *Operating (or Hot) VSWR* — The VSWR of the input (or output) of a microwave amplifier tube observed under operating conditions.

13.6 Loss

13.6.1 *Cold Loss* — The attenuation which occurs between the input and output terminals of a microwave amplifier tube under cold conditions.

13.6.2 *Operating Loss* — The attenuation which occurs from the output terminal to the input terminal of a microwave amplifier tube under operating conditions.

13.7 Phase Sensitivity to Voltage or Current — The rate of change of the phase of the radio frequency output signal relative to the driving signal with respect to the voltage or current of a specified electrode, while the driving power and all the other operating voltages are maintained constant.

13.8 Stability

13.8.1 *Short-Circuit Stability* — The ability of a microwave amplifier tube, when operated under stated conditions, to ensure a stable performance without unwanted oscillations, when the radio frequency input and/or the radio frequency output is/are short-circuited, and the phases of the reflection coefficients are independently varied through at least 2π radians.

13.9 Cross Modulation — The modulating of a wanted signal by the modulation of an unwanted signal on a different carrier frequency, arising from interaction of the signals due to the non-linear characteristics of an active electronic device.

13.10 Intermodulation — Modulation of the components of a complex wave by each other in an electron tube of non-linear transfer characteristics resulting in generation of new frequencies in the output wave.

13.11 Intermodulation Products — Output components at new frequencies, generated by intermodulation.

NOTE — The frequency of these components can be realized mathematically by the sums and differences of multiples of the component frequencies of the complex wave at the input. Thus, for input frequencies $f1$, $f2$ and $f3$, the frequencies of intermodulation products are ($pf1 + qf2 + rf3$), where p, q and r are positive integers.

13.12 Intermodulation Ratio — The ratio of a stated reference power level and the power level of a stated intermodulation product.

NOTE — It is a measure of the magnitude of intermodulation products.

13.13 AM-PM Conversion — A process in which the phase shift between the output and input waves depends upon the amplitude of the input wave.

13.14 AM-PM Conversion Coefficient — The ratio of the change of phase of the radio frequency output voltage relative to the radio frequency input voltage, and the change of radio frequency input power at a constant mean value of radio frequency output power.

13.15 AM-PM Transfer — A process in which the phase shift between the output voltage and the input voltage of one carrier depends upon the magnitude of the radio frequency input power of any other carrier passing simultaneously through an amplifier tube.

13.16 AM-PM Transfer Coefficient — The ratio of the change of phase difference between the radio frequency input voltage and radio frequency output voltage of one carrier, and the change of radio frequency input power of another carrier passing simultaneously through the tube.

13.17 AM-AM Transfer — The variation which occurs in the amplitude of one signal carrier due to amplitude variations of a second signal carrier when both carriers are passing simultaneously through the microwave amplifier tube.

NOTE — This is a kind of cross modulation.

13.18 AM-AM Transfer Coefficient or Factor — The ratio of the change in power of one carrier due to a change in power of a second carrier, and the change in power of the second carrier.

13.19 Differential Phase — The difference in phase-shift of a small high-frequency modulating signal at two stated levels (or frequencies) of a coexisting large lower-frequency modulating signal.

NOTE — The combination of a high- and a low-frequency signal (usually a saw-tooth) is used for modulating the radio frequency carrier.

13.20 Transient Signal Distortion — The maximum deviation of the output envelope from the approximate form of a step function applied to the input.

14. TERMS APPLICABLE TO OSCILLATOR TUBES

14.1 Frequency Drift — A slow continuous change of frequency of oscillation.

14.1.1 *Warm-Up Frequency Drift* — The frequency drift of a microwave oscillator tube which occurs during total starting time or a stated warm-up time.

14.2 Frequency Pushing — The phenomenon of the change in the frequency of oscillation, with the change of an electrode current.

14.2.1 *Pushing Figure* — The ratio of the difference between the extremes of frequency of oscillation, and the change in electrode current which produced the change in frequency, thermal effects being excluded. Numerically, the frequency-pushing figure is expressed in megahertz per ampere.

14.3 Frequency Pulling — The phenomenon of the change in the frequency of oscillation, with a change of load impedance.

14.3.1 *Pulling Figure* — The difference between the extremes of frequency of oscillation occurring when the phase of the reflection coefficient of a given load mismatch is varied through 2 π radians (thermal effects excluded).

14.4 Temperature Coefficient of Frequency — The ratio of the change in the frequency of oscillation, and the change of the temperature which caused it. The temperature is measured at a stated point of the tube body.

14.5 Mode Separation — The frequency difference between resonator modes of oscillation in a microwave oscillator tube.

14.6 Voltage Coefficient of Frequency — The ratio of the change in frequency of oscillation, and the causative change of voltage at a stated electrode, thermal effects excluded.

NOTE — If the stated electrode is intended for frequency-controlling purposes, the voltage coefficient of frequency is called electronic tuning sensitivity.

15. TERMS APPLICABLE TO DISK SEAL TUBES

15.1 Diode Limit Frequency — The lower frequency at which the rectified voltage across the load resistor differs by a stated amount (usually

3 dB) from that voltage which is obtained at low frequencies, the applied radio frequency voltage being maintained constant.

15.2 Frequency Position — The resonant frequency of an individual tube when the tube is measured in a standard circuit as defined in **15.4**, **15.5** and **15.6**. The frequency position is expressed either as a frequency or as a deviation from a given nominal frequency.

15.2.1 *Frequency Spread* — The spread in frequency position.

15.3 Self-Neutralization Frequency — The frequency at which the reverse transfer admittance (internal feedback) of the tube is a minimum.

15.4 Standard Anode Circuit — A radial cavity of precisely defined dimensions, connected between anode and grid contact surfaces and which, together with the tube, creates a resonant circuit.

15.5 Standard Cathode Circuit — A coaxial or radial cavity of precisely defined dimensions, connected between the cathode and grid contact surfaces and which together with the tube, creates a resonant circuit.

15.6 Standard Screen-Grid Circuit — A coaxial cavity of precisely defined dimensions, connected between the screen grid and control grid contact surfaces and which, together with the tube, creates a resonant circuit.

16. TERMS APPLICABLE TO MAGNETRONS

16.1 Pi-Mode — The mode of operation in which the phase difference between adjacent cavities is π radians.

16.2 Runaway — An uncontrolled increase of anode current of fixed or decreasing anode voltage, resulting in a fall in efficiency due to the inherent self-actuating thermal effects in a magnetron operating under present conditions.

16.3 Moding — The operation of a magnetron, partly or fully, in any undesired mode.

16.4 Voltage at Reduced Current — The voltage at which a stated fraction (usually 5 to 10 percent) of the operating current flows through the magnetron.

16.5 Incidental FM — Random or periodic variations (or both) in the frequency of oscillation produced by unexplained inherent causes.

NOTE — This is a form of noise.

16.6 Restarting Ability — The ability of a magnetron to re-establish its original average anode current and/or output power when the initial starting procedure and conditions are re-applied after interruption of all the supply voltages for a period enough to allow the cathode to cool completely.

16.7 Emmission Stability (of a Magnetron) — The ability of a magnetron to continue oscillation in the desired mode when heater or filament power is reduced by a stated amount (*see also* **9.3.11**).

16.8 Heater Schedule — The relation between heater voltage and anode input power, which shall be maintained in order to avoid destruction of the magnetron cathode by electron bombardment.

16.9 Critical (or Cut-Off) Magnetic Field (of a Magnetron) — The smallest theoretical value of the static magnetic field at a given steady anode voltage that would prevent electrons emitted from the cathode with zero velocity, from reaching the anode.

16.10 Critical Voltage (of a Magnetron) — The highest theoretical value of the steady anode voltage at a given static magnetic field at which electrons emitted from the cathode with zero velocity would fail to reach the anode.

16.11 Magnetron Cut-Off — The condition of zero (ideally) anode current in a magnetron when subjected to the critical magnetic field.

16.12 Performance Chart (of a Magnetron) — A plot on coordinates of applied anode voltage and current, showing contours of constant magnetic field, power output, and efficiency.

16.13 Strapping — Process whereby alternate anode segments are connected together by means of conductors (or straps) in such a manner so as to maintain fixed phase relationship between the oscillations of various resonators.

NOTE — Depending on the extent of the degree of strapping, it is further classified as light or heavy strapping.

17. TERMS APPLICABLE TO KLYSTRONS

17.1 Mechanical Tuning Range — The continuous frequency range between the two frequencies at which the output power is a stated fraction (usually 0·5) of the optimum power obtained at a reference frequency within the range, all voltages being maintained constant.

17.2 Electronic Tuning Range of a Klystron — The continuous frequency range between the two frequencies at which the output power is a stated fraction, usually 0·5, of the output power at the mode centre under stated operating conditions, only the electronic tuning voltage being varied.

17.3 Mode Centre — The point on the electronic tuning characteristic for a chosen mode at which the output power has the maximum value.

17.4 Electronic Tuning Non-linearity Factor — The ratio of the difference between the larger value of the tuning sensitivity obtained at two stated frequencies equally spaced from the mode centre, and the tuning sensitivity at the mode centre.

17.5 Reflector or Repeller (of a Reflex Klystron) — The electrode at negative potential with respect to the cathode, which reverses the direction of the electron beam.

17.6 Total Reflector Current — The current flowing in the reflector circuit which includes:

a) leakage current,
b) gas current, and
c) current caused by the electron bombardment of the reflector electrode.

17.7 Bunching Parameter — A function that defines the degree of bunching and the waveform of the density-modulated beam. It is equal to one-half the product of the bunching angle (effective bunching angle in the case of a reflex Klystron) in the absence of velocity modulation, and the depth of velocity modulation.

17.8 Drift-Space Bunching — Bunching that occurs arising out of changes in velocity causing electron displacement in the field-free drift space as a function of time.

Example :

Double-resonator klystron.

17.9 Reflector Bunching — Bunching that occurs arising out of changes in the velocity causing electron displacement in the reflecting space, as a function of time.

Example :

Reflex klystron.

18. TERMS APPLICABLE TO FORWARD-WAVE AMPLIFIER TUBES, O-TYPE

18.1 $\triangle$V-PM Conversion Coefficient — The rate of change of the phase of the radio frequency output voltage relative to the radio frequency input voltage, with respect to a specific electrode operating voltage, while the radio frequency driving power and all other operating voltages are maintained constant.

NOTE — This is also called ‘ voltage phase ’ sensitivity.

INDEX

NOTE — This index has been prepared in accordance with IS : 1275-1958[*]. Index numbers are clause numbers.

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[*] Rules for making alphabetical indexes.

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1885 (Part IV/Sec 1)-1965	Electrotechnical vocabulary: Part IV Electron tubes and valves, Section 1 Receiving valves
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1885 (Part IV/Sec 4)-1970	Electrotechnical vocabulary: Part IV Electron tubes and valves, Section 4 Cathode ray tubes
2032 (Part IX)-1969	Graphical symbols used in electrotechnology: Part IX Electron tubes and valves (other than microwave tubes and valves)
2032 (Part XIII)-1971	Graphical symbols used in electrotechnology: Part XIII Miscrowave tubes
2597 (Part I)-1964	Code of practice for the use of electronic valves: Part I Commercial receiving valves
2597 (Part II)-1967	Code of practice for use of electronic valves: Part II Special quality valves
2597 (Part III)-1969	Code of practice for the use of electronic valves: Part III Transmitting and industrial valves
2597 (Part IV)-1970	Code of practice for the use of electronic valves: Part IV Cathode ray tubes
2597 (Part V)-1971	Code of practice for the use of electronic valves: Part V Rectifiers and thyristors
2612-1965	Recommendation for type approval and sampling procedures for electronic components
2684 (Part I)-1971	Dimensions of electronic valves: Part I Miniature 9-pin noval type
2684 (Part II)-1971	Dimensions of electronic valves: Part II Miniature 7-pin type
2684 (Part III)-1971	Dimensions of electronic valves: Part III Octal base type
2684 (Part IV)-1971	Dimensions of electronic valves: Part IV Magnoval base type
3154-1965	X-ray tubes, diagnostic type
4096-1967	Method of measurement of optical focal spot size of X-ray tubes
4147-1967	Method of measurements on conventional receiving electronic valves
4579-1968	Methods of measurements on television picture tubes
4697-1968	Methods of measurements on Geiger-Müller counter tubes
5323-1969	Letter symbols and abbreviations for electron tubes and valves
5627-1970	Methods of measurements on cathode ray display tubes
5840 (Part I)-1970	Dimensions of cathode-ray tubes: Part I Tube outlines
5840 (Part II)-1970	Dimensions of cathode-ray tubes: Part II Bases
5840 (Part III)-1970	Dimensions of cathode-ray tubes: Part III EHT Terminals
6214-1971	Standard phosphors for cathode-ray tubes

INDIAN STANDARDS INSTITUTION

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 1

Telephone : 27 01 31 (20 lines)

Telegrams : Manaksanstha

Branch Offices:

Branch Offices		Telephone
'Sadhna' Tulsivihar, Khanpur	Ahmedabad 1	—
F Block, Unity Bldg, Narasimharaja Square	Bangalore 2	2 76 49
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5 Chowringhee Approach	Calcutta 13	23-0802
5-9-201/2-A (First Floor), Chirag Ali Lane	Hyderabad 1	5 34 35
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Section 3 Microwave Tubes and Valves

Alteration

(*Page* 42, Composition of ETDC 39 : P4) — Substitute the following composition for the existing matter:

Panel for Microwave Tubes, ETDC 39 : P5

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Alterations

(*First cover page, pages* 1 *and* 3, *Title*) — Substitute the following for the existing title:

' *Indian Standard*

ELECTROTECHNICAL VOCABULARY

PART IV ELECTRON TUBES

Section 3 Microwave Tubes'

Substitute ' Electron tubes ' for ' Electronic Valves ' and ' Electron Tubes and Valves ' wherever it appears in the standard.

Substitute ' tube ' *for* ' valve ' wherever it appears in the standard.

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PART IV ELECTRON TUBES

Section 3 Microwave Tubes

Addenda

(*Page* 8, *clause* **3.7.5**) — Add the following new clause after **3.7.5**:

'**3.7.6** *Permanent Magnetic Integral (Packaged) Magnetron* — An integral (packaged) magnetron in which the magnetron field is provided by a permanent magnet.'

(*Page* 18, *clause* **9.3.6**) — Add the following new clause after **9.3.6** and re-number the subsequent clauses:

'**9.3.7** *Minor Lobe Ratio* — The ratio of the amplitude of the major lobe and the amplitude of the highest minor lobe, expressed in dB (*see* Fig. 1 and 2).'

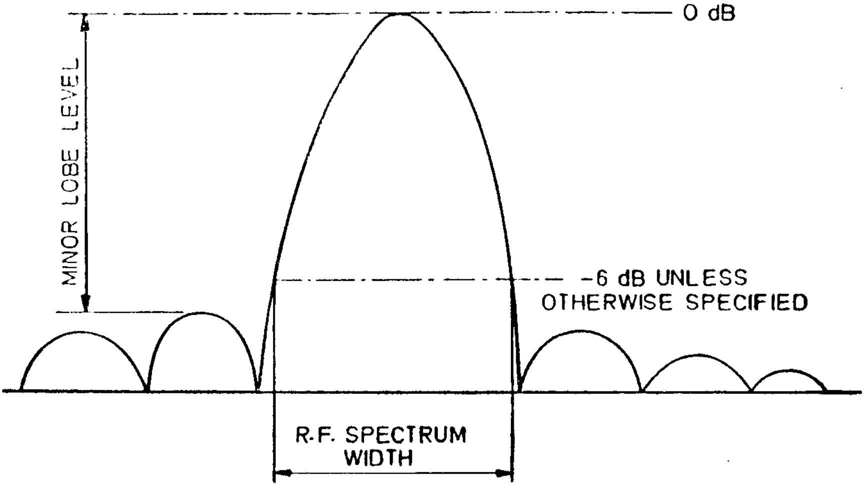

FIG. 1 R. F. SPECTRUM WIDTH (HIGHEST MINOR LOBE BELOW SPECTRUM WIDTH REFERENCE LEVEL)

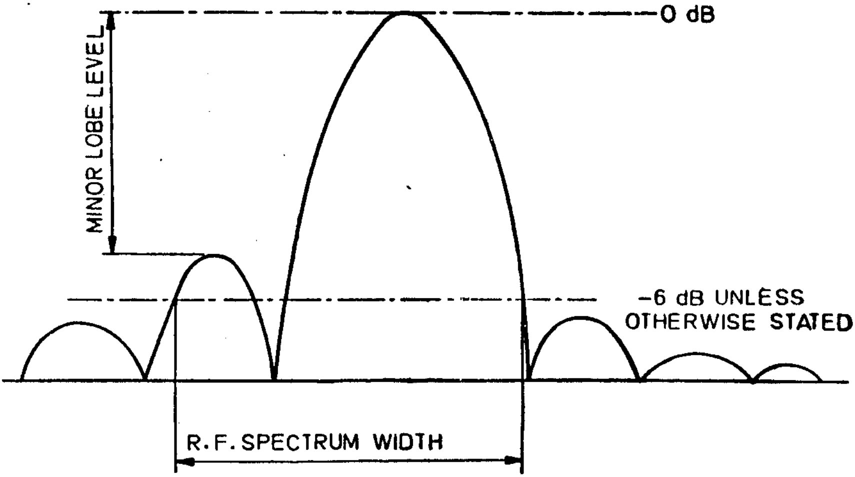

Fig. 2 R. F. Spectrum Width (Highest Minor Lobe Exceeds Spectrum Width Reference Level)

(LTDC 9)

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